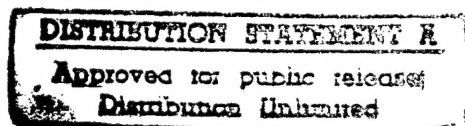


FINAL REPORT  
FEBRUARY 1997

REPORT NO. 97-09

FUTURE ARMOR TILES  
MIL-STD-1660 TESTS



19970616 033

Prepared for:  
U.S. Army Defense Ammunition  
Center  
ATTN: SIOAC-DES  
Savanna, IL 61074-9639

Distribution Unlimited

U.S. ARMY

19970616 033



VALIDATION ENGINEERING DIVISION  
SAVANNA, ILLINOIS 61074-9639



### AVAILABILITY NOTICE

A copy of this report will be furnished each attendee on automatic distribution. Additional copies or authority for reprinting may be obtained by written request from Director, U.S. Army Defense Ammunition Center, ATTN: SIOAC-DEV, Savanna, IL 61074-9639.

### DISTRIBUTION INSTRUCTIONS

Destroy this report when no longer needed. Do not return.

\*\*\*

Citation of trade names in this report does not constitute an official endorsement.

\*\*\*

The information contained herein will not be used for advertising purposes.

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE				Form Approved OMB No. 0704-0188	
1a. REPORT SECURITY CLASSIFICATION <b>UNCLASSIFIED</b>			1b. RESTRICTIVE MARKINGS		
2a. SECURITY CLASSIFICATION AUTHORITY			<b>UNLIMITED</b>		
2b. DECLASSIFICATION / DOWNGRADING SCHEDULE					
4. PERFORMING ORGANIZATION REPORT NUMBER(S) <b>97-09</b>			5. MONITORING ORGANIZATION REPORT NUMBER(S)		
6a. NAME OF PERFORMING ORGANIZATION <b>U.S. Army Defense Ammunition Center</b>		6b. OFFICE SYMBOL (if applicable) <b>SIOAC-DEV</b>	7a. NAME OF MONITORING ORGANIZATION		
6c. ADDRESS (City, State, and ZIP Code) <b>ATTN: SIOAC-DEV Savanna, IL 61074-9639</b>			7b. ADDRESS (City, State, and ZIP Code)		
8a. NAME OF FUNDING / SPONSORING ORGANIZATION <b>U.S. Army Defense Ammunition Center</b>		8b. OFFICE SYMBOL (if applicable) <b>SIOAC-DES</b>	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER		
8c. ADDRESS (City, State, and ZIP Code) <b>ATTN: SIOAC-DES Savanna, IL 61074-9639</b>			10. SOURCE OF FUNDING NUMBERS		
			PROGRAM ELEMENT NO.	PROJECT NO.	TASK NO.
					WORK UNIT ACCESSION NO.
11. TITLE (Include Security Classification) <b>Future Armor Tiles MIL-STD-1660 Tests</b>					
12. PERSONAL AUTHOR(S) <b>A. C. McIntosh, Jr.</b>					
13a. TYPE OF REPORT <b>Final</b>		13b. TIME COVERED FROM _____ TO _____		14. DATE OF REPORT (Year, Month, Day) <b>1997 February</b>	
15. PAGE COUNT					
16. SUPPLEMENTARY NOTATION					
17. COSATI CODES			18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)		
FIELD	GROUP	SUB-GROUP			
19. ABSTRACT (Continue on reverse if necessary and identify by block number)					
<p>The U.S. Army Defense Ammunition Center (DAC), Validation Engineering Division (SIOAC-DEV), was tasked by DAC, Supply Engineering Division (SIOAC-DES), to conduct MIL-STD-1660 tests on armor tile containers on a wooden pallet. This report contains test results with the armor tile containers on a wooden pallet meeting MIL-STD-1660, Design Criteria for Ammunition Unit Loads, requirements.</p>					
20. DISTRIBUTION / AVAILABILITY OF ABSTRACT <input checked="" type="checkbox"/> UNCLASSIFIED/UNLIMITED <input type="checkbox"/> SAME AS RPT. <input type="checkbox"/> DTIC USERS			21. ABSTRACT SECURITY CLASSIFICATION <b>UNCLASSIFIED</b>		
22a. NAME OF RESPONSIBLE INDIVIDUAL <b>JEROME H. KROHN</b>			22b. TELEPHONE (Include Area Code) <b>815-273-8929</b>		22c. OFFICE SYMBOL <b>SIOAC-DEV</b>

U.S. ARMY DEFENSE AMMUNITION CENTER  
VALIDATION ENGINEERING DIVISION  
SAVANNA, IL 61074-9639

REPORT NO. 97-09

FUTURE ARMOR TILES MIL-STD-1660 TESTS

TABLE OF CONTENTS

PART	PAGE NO.
1. INTRODUCTION .....	1-1
A. BACKGROUND .....	1-1
B. AUTHORITY .....	1-1
C. OBJECTIVE .....	1-1
D. CONCLUSION .....	1-1
2. ATTENDEES .....	2-1
3. TEST PROCEDURES .....	3-1
4. TEST EQUIPMENT .....	4-1
5. TEST RESULTS .....	5-1
6. PHOTOGRAPH .....	6-1
7. DRAWING .....	7-1

## PART 1

### INTRODUCTION

A. BACKGROUND. The U.S. Army Defense Ammunition Center (DAC), Validation Engineering Division (SIOAC-DEV), was tasked by DAC, Supply Engineering Division (SIOAC-DES), to conduct MIL-STD-1660 tests on a wooden pallet designed for future armor tile containers.

B. AUTHORITY. These tests were conducted IAW mission responsibilities delegated by the U.S. Army Armament, Munitions and Chemical Command (AMCCOM), Rock Island, IL.

C. OBJECTIVE. The objective of these tests was to determine whether the wooden pallet design for the future armor tile containers is capable of meeting MIL-STD-1660, Design Criteria for Ammunition Unit Loads, requirements.

D. CONCLUSION. The palletized unit load completed testing with the palletized unit load intact. The palletized unit load passed MIL-STD-1660, Design Criteria for Ammunition Unit Loads, requirements.

PART 2

31 JANUARY 1997

ATTENDEES

A. C. McIntosh, Jr.  
General Engineer  
DSN 585-8989  
815-273-8989

Director  
U.S. Army Defense Ammunition Center  
3700 Army Depot Road  
ATTN: SIOAC-DEV  
Savanna, IL 61074-9639

Bradley J. Haas  
Mechanical Engineer  
DSN 585-8336  
815-273-8336

Director  
U.S. Army Defense Ammunition Center  
3700 Army Depot Road  
ATTN: SIOAC-DEV  
Savanna, IL 61074-9639

Sandra M. Schultz.  
Industrial Engineer  
DSN 585-8086  
815-273-8086

Director  
U.S. Army Defense Ammunition Center  
3700 Army Depot Road  
ATTN: SIOAC-DES  
Savanna, IL 61074-9639

Betty J. Kundert  
Engineering Draftsman  
DSN 585-8095  
815-273-8095

Director  
U.S. Army Defense Ammunition Center  
3700 Army Depot Road  
ATTN: SIOAC-DES  
Savanna, IL 61074-9639

## PART 3

### TEST PROCEDURES

The test procedures outlined in this section were extracted from MIL-STD-1660, Design Criteria for Ammunition Unit Loads, 8 April 1977. This standard identifies nine steps that a unitized load must undergo if it is to be considered acceptable. The five tests that were conducted on the test pallets are summarized below.

A. STACKING TESTS. The unit load was loaded to simulate a stack of identical unit loads stacked 16 feet high, for a period of one hour. This stacking load was simulated by subjecting the unit load to a compression weight equal to an equivalent 16-foot stacking height. The compression load was calculated in the following manner. The unit load weight was divided by the unit load height in inches and multiplied by 192. The resulting number was the equivalent compressive force of a 16-foot-high load.

B. REPETITIVE SHOCK TEST. The repetitive shock test was conducted IAW Method 5019, Federal Standard 101. The test procedure is as follows: The test specimen was placed on, but not fastened to, the platform. With the specimen in one position, the platform was vibrated at 1/2-inch amplitude (1-inch double amplitude) starting at a frequency of approximately 3 cycles per second. The frequency was steadily increased until the package left the platform. The resonant frequency was achieved when a 1/16-inch-thick feeler gage momentarily slid freely between every point on the specimen in contact with the platform at some instance during the cycle or a platform acceleration achieved  $1 \pm 0.1$  Gs. Midway into the testing period, the specimen was rotated 90 degrees and the test continued for the duration. Unless failure occurred, the total time of vibration was two hours if the specimen was tested in one position and three hours for more than one position.

C. EDGEWISE ROTATIONAL DROP TEST. This test was conducted using the procedures of Method 5008, Federal Standard 101. The procedure for the edgewise rotational drop test is as follows: The specimen was placed on its skids with one end of the pallet supported on a beam 4-1/2 inches high. The height of the beam was increased if necessary to ensure that there was no support for the skids between the ends of the pallet when dropping took place, but was not high enough to cause the pallet to slide on the supports when the dropped end was raised for the drops. The unsupported end of the pallet was then raised and allowed to fall freely to the concrete, pavement, or similar underlying surface from a prescribed height. Unless otherwise specified, the height of drop for level A protection conforms to the following tabulation:

GROSS WEIGHT (WITHIN RANGE LIMITS) (Pounds)	DIMENSIONS OF ANY EDGE, HEIGHT OR WIDTH (WITHIN RANGE LIMITS) (Inches)	HEIGHT OF DROPS ON EDGES	
		Level A (Inches)	Level B (Inches)
150 - 250	60 - 66	36	27
250 - 400	66 - 72	32	24
400 - 600	72 - 80	28	21
600 - 1000	80 - 95	24	18
1000 - 1500	95 - 114	20	16
1500 - 2000	114 - 144	17	14
2000 - 3000	Above 145 - No limit	15	12
Above - 3000		12	9



## PART 4

### TEST EQUIPMENT

#### A. Armor Tile Containers on a Wooden Pallet.

- |                         |                      |
|-------------------------|----------------------|
| 1. Pallet Width:        | 29 inches            |
| 2. Pallet Length:       | 55 inches            |
| 3. Unit Load Height:    | 19-1/4 inches        |
| 4. Unit Load Weight:    | 810 pounds           |
| 5. Container Restraint: | Intermediate Banding |

#### B. Compression Tester

- |                       |                      |
|-----------------------|----------------------|
| 1. Manufacturer:      | Ormond Manufacturing |
| 2. Platform:          | 60- by 60-inches     |
| 3. Compression Limit: | 50,000 pounds        |
| 4. Tension Limit:     | 50,000 pounds        |

#### C. Transportation Simulator

- |                  |                    |
|------------------|--------------------|
| 1. Manufacturer: | Gaynes Laboratory  |
| 2. Capacity:     | 6,000-pound pallet |
| 3. Displacement: | 1/2-inch amplitude |
| 4. Speed:        | 50 to 400 rpm      |
| 5. Platform:     | 5- by 8-foot       |

#### D. Incline Plane

- |                  |                    |
|------------------|--------------------|
| 1. Manufacturer: | Conbur Incline     |
| 2. Type:         | Impact Tester      |
| 3. Grade:        | 10 percent incline |
| 4. Length:       | 12-foot            |

## PART 5

### TEST RESULTS

A. TEST OBSERVATIONS. The test sample was loaded with armor tile containers on a wooden pallet.

B. STACKING TEST. The test sample was initially loaded to 7,600 pounds compression. The compression was released after one hour. No damage was noted during this test.

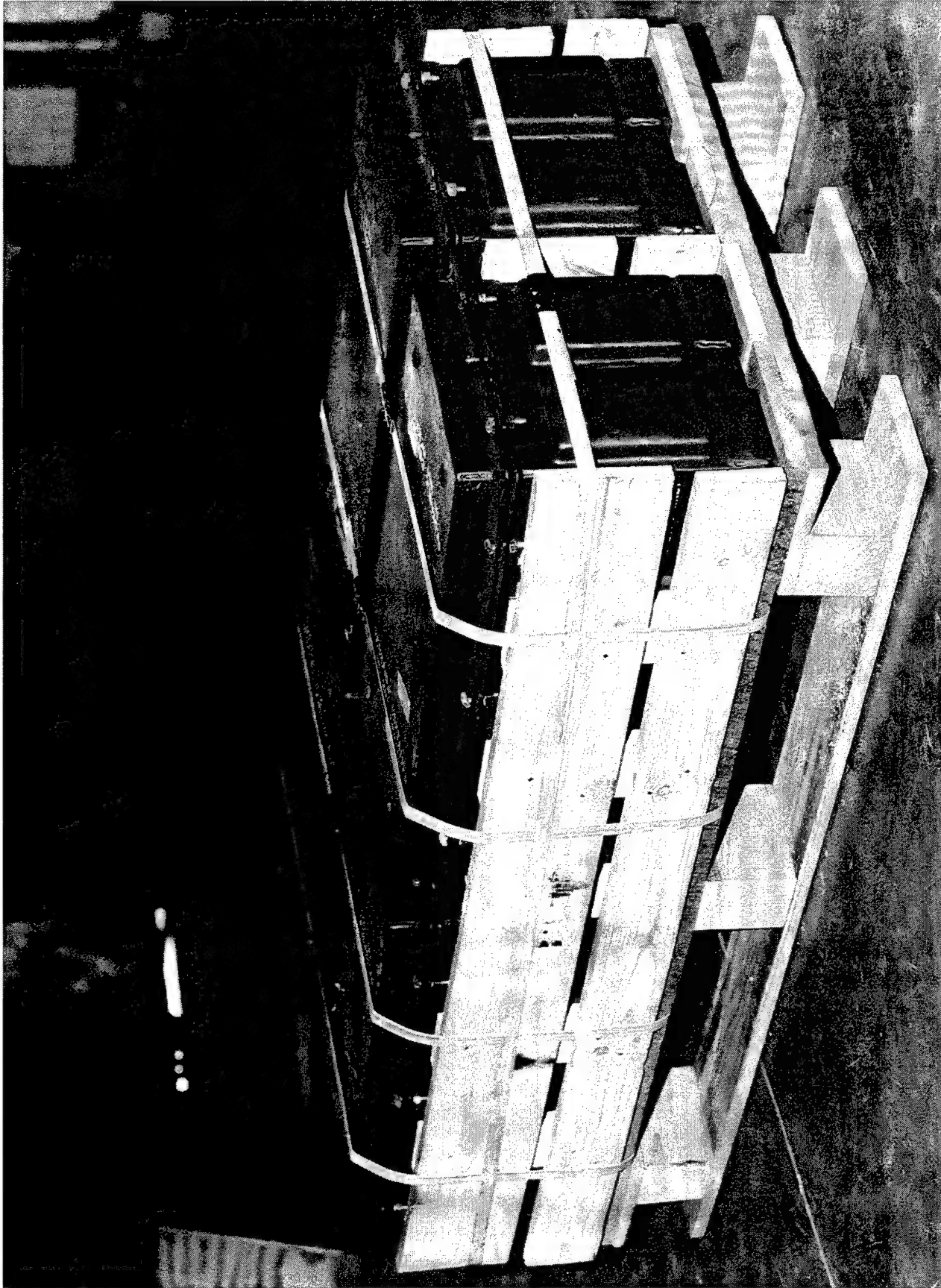
C. REPETITIVE SHOCK TEST. The duration of the test was 90 minutes for each orientation of the pallet. The transportation simulator was operated at 238 rpm while the pallet was oriented in the lateral direction. For the longitudinal orientation, the transportation simulator was operated at 264 rpm. No load movement or damage was observed.

D. EDGEWISE ROTATIONAL DROP TEST. One side of the pallet was placed on a beam displacing it 4-1/2 inches above the floor. The opposite end of the pallet was raised to a height of 24 inches, then dropped. No damage was observed after dropping the pallet from a height of 24 inches on all four sides.

E. INCLINE-IMPACT TEST. The inclined plane was set to allow the pallets to travel 8 feet prior to impacting a stationary wall. The pallet was rotated clockwise after each impact, until all four sides had been tested. No damage resulted from any of the four impacts.

PART 6

PHOTOGRAPH



	U.S. ARMY DEFENSE AMMUNITION CENTER AND SCHOOL - SAVANNA, IL	
PHOTO NO. AO317-SCN97-1516: This photo shows the future armor tile pallet after being tested to MIL-STD-1660 requirements. The unit did not sustain any damage as a result of these tests.		

PART 7

DRAWING

UNITIZATION PROCEDURES FOR FUTURE  
 ARMOR TILE, PACKED VARIOUS  
 QUANTITIES PER METAL SHIPPING  
 AND STORAGE CONTAINER, UNITIZED  
 4 CONTAINERS PER 27-1/2" X 55"  
 SPECIAL PALLET; APPROX CONTAINER  
 SIZE 27-1/4" L X 13-3/4" W X  
 13-7/16" H

DISTRIBUTION STATEMENT A.

APPROVED FOR PUBLIC RELEASE;  
 DISTRIBUTION IS UNLIMITED.

U.S. ARMY MATERIEL COMMAND DRAWING				
APPROVED, U.S. ARMY INDUSTRIAL OPERATIONS COMMAND		DRAFTSMAN		BETTY J. KUNDERT
		ENGINEER		SANDRA M. SCHULTZ
<div style="display: flex; justify-content: space-between;"> <div>AMSTA-AR-ESK</div> <div>AMSIO-TMJ</div> </div>		SUPPLY ENGINEERING DIVISION	TRANSPORTATION ENGINEERING DIVISION	VALIDATION ENGINEERING DIVISION
		LOGISTICS ENGINEERING OFFICE		
APPROVED BY ORDER OF COMMANDING GENERAL, U.S. ARMY MATERIEL COMMAND  U.S. ARMY DEFENSE AMMUNITION CENTER		FEBRUARY 1997		
		CLASS	DIVISION	DRAWING
		19	48	4221/7
				20PA 1009

DO NOT SCALE

PALLET UNIT DATA				
ITEMS INCLUDED		HAZARD CLASS AND DIVISION •		APPROX WEIGHT LBS
NSN	DDIC	DD CLASS	COMP GROUP	
1375- - -	----	-. -	-	802

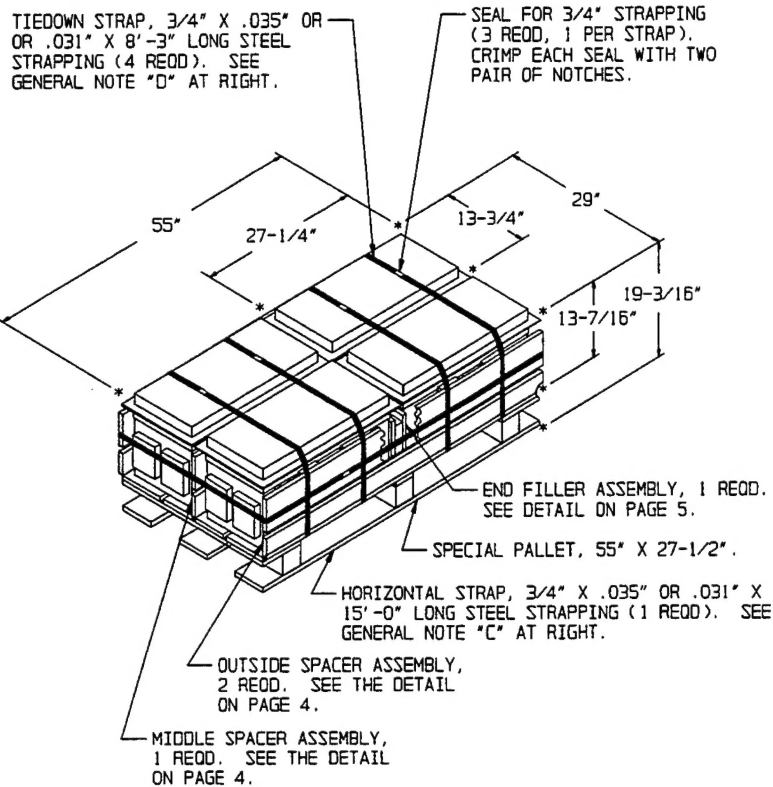
- HAZARD CLASSIFICATION DATA CONTAINED IN THE ABOVE CHART IS FOR GUIDANCE AND INFORMATIONAL PURPOSES ONLY. VERIFICATION OF THE SPECIFIED DATA SHOULD BE MADE BY CONSULTING THE MOST RECENT JOINT HAZARD CLASSIFICATION SYSTEM LISTING OR OTHER APPROVED LISTING(S).

## GENERAL NOTES

- THIS DOCUMENT HAS BEEN PREPARED AND ISSUED IN ACCORDANCE WITH AR 740-1 AND AUGMENTS TM 743-200-1 (CHAPTER 5) AND CONFORMS TO MIL-STD-1660.
- DIMENSIONS, CUBE AND WEIGHT OF A PALLET UNIT WILL VARY SLIGHTLY DEPENDING UPON THE ACTUAL DIMENSIONS OF THE BOXES AND THE WEIGHT OF THE SPECIFIC ITEM BEING UNITIZED.
- INSTALL THE HORIZONTAL STRAP TO BE LOCATED AS SHOWN. THE HORIZONTAL STRAP MUST BE TENSIONED AND SEALED AFTER THE APPLICATION OF TIEDOWN STRAPS.
- INSTALL EACH TIEDOWN STRAP TO PASS UNDER THE DECK BOARDS OF THE PALLET AND TO BE LOCATED AS SHOWN. TIEDOWN STRAPS MUST BE TENSIONED AND SEALED PRIOR TO APPLICATION OF HORIZONTAL STRAPS.
- THE FOLLOWING AMC DRAWINGS ARE APPLICABLE FOR OUTLOADING AND STORAGE OF THE ITEMS COVERED BY THIS APPENDIX.

CARLOADING - - - - 19-48-4115-5PA1002  
 TRUCKLOADING - - - - 19-48-4117-11PA1003  
 STORAGE - - - - 19-48-4125-1-2-3-4-14-22PA1002  
 END OPENING ISO  
 CONTAINER - - - - 19-48-4153-15PA1002  
 MILVAN - - - - 19-48-4166-15PA1003  
 SIDE OPENING ISO  
 CONTAINER - - - - 19-48-4267-15PA1009

- IF ITEMS COVERED HEREIN ARE UNITIZED PRIOR TO ISSUANCE OF THIS APPENDIX, THE BOXES NEED NOT BE REUNITIZED SOLELY TO CONFORM TO THIS APPENDIX.
- WHEN APPLYING ANY STRAP, CARE MUST BE EXERCISED TO ASSURE THAT THE END OF THE STRAP ON THE UNDERSIDE OF THE JOINT EXTENDS AT LEAST 6" BEYOND THE SEAL. THIS EXTRA MINIMUM LENGTH OF STRAP IS REQUIRED TO PERMIT SUBSEQUENT TIGHTENING OF LOOSENED STRAPPING. RETENSIONING CAN BE ACCOMPLISHED WITHOUT REPLACING STRAPPING OR SPLICING STRAPPING THROUGH THE USE OF A FEEDWHEEL TENSIONING TOOL, MANUAL OR PNEUMATIC, AND THE APPLICATION OF ONE ADDITIONAL SEAL.
- ALL DUNNAGE SHALL BE PRESERVATIVE TREATED IN ACCORDANCE WITH THE PROCEDURES SPECIFIED IN MIL-B-2427 FOR CLEATED WOODEN BOXES. IF THE DUNNAGE CONSISTS OF MORE THAN ONE COMPONENT, IT MUST BE ASSEMBLED PRIOR TO TREATMENT. THE LETTERS PA DENOTING P056 (COPPER-8-QUINOLINOLATE), PB DENOTING M-GARD W550 (ZINC NAPHTHENATE EMULSIFIABLE) OR PC DENOTING M-GARD W510 OR CUNAPSOL 5 (COPPER NAPHTHENATE) MUST BE APPLIED TO THE WOOD DUNNAGE IN LETTERS AT LEAST ONE INCH HIGH.
- A PLUS OR MINUS 1/4" IS ALLOWED ON OVERALL DIMENSIONS OF ANY DUNNAGE ASSEMBLY. HOWEVER, SIMILAR PIECES IN AN ASSEMBLY MUST BE WITHIN 1/8" OF THE SAME DIRECTION.
- IN ORDER TO OBTAIN COMPACT (SOUND) UNITS, ALL STRAPS SHALL BE LOCATED IN PROPER ALIGNMENT AND TENSIONED UNTIL THEY CUT INTO THE EDGE OF THE PALLET DECK. AFTER TENSIONING, ALL STRAPS WILL BE SECURED USING ONE SEAL AND TWO PAIR OF NOTCHES.
- DIMENSIONAL LUMBER SPECIFIED THROUGHOUT THIS PROCEDURAL DRAWING IS OF NOMINAL SIZE UNLESS OTHERWISE SPECIFIED. FOR EXAMPLE, 1" X 4" MATERIAL IS ACTUALLY 3/4" THICK BY 3-1/2" WIDE AND 2" X 4" MATERIAL IS ACTUALLY 1-1/2" THICK BY 3-1/2" WIDE.
- FOR DETAILS OF THE METAL SHIPPING AND STORAGE CONTAINER SEE DRAWING 9342676.
- THE METAL SHIPPING AND STORAGE CONTAINERS MUST BE POSITIONED WITH THE HUMIDITY INDICATORS FACING INWARD TOWARDS THE MIDDLE.



## PALLET UNIT

SEE GENERAL NOTE "A" AT RIGHT.

4 CONTAINERS OF FUTURE ARMOR TILES AT 175 LBS - - - - -	700 LBS (APPROX)
DUNNAGE - - - - -	47 LBS
PALLET - - - - -	55 LBS
<b>TOTAL WEIGHT - - - - -</b>	<b>802 LBS (APPROX)</b>
<b>CUBE - - - - -</b>	<b>17.7 CU FT (APPROX)</b>

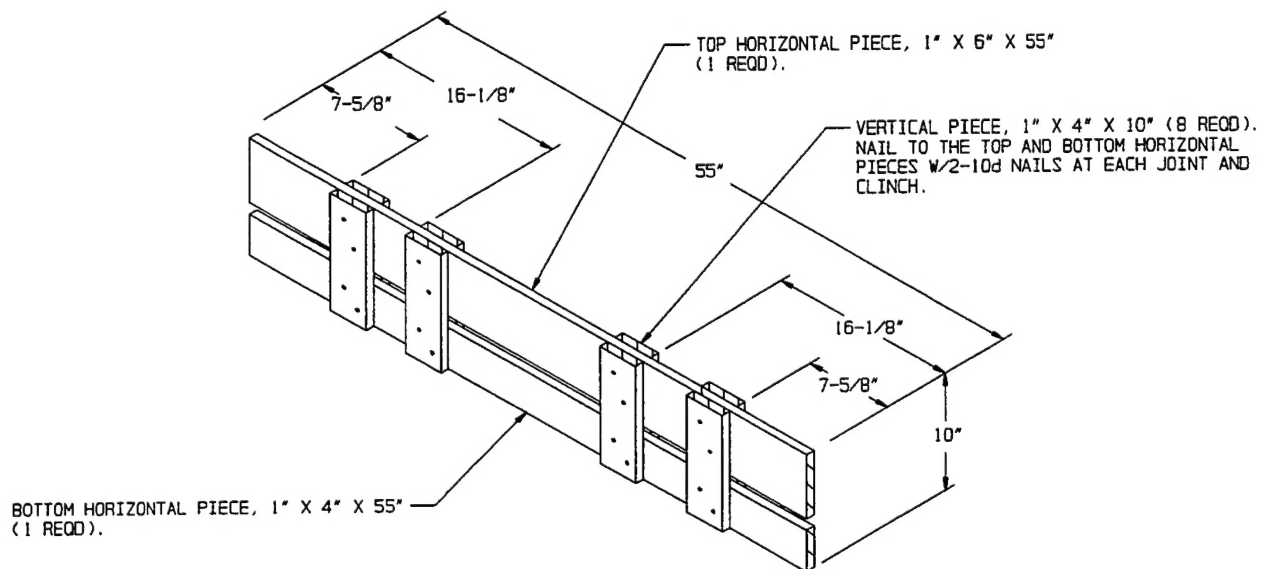
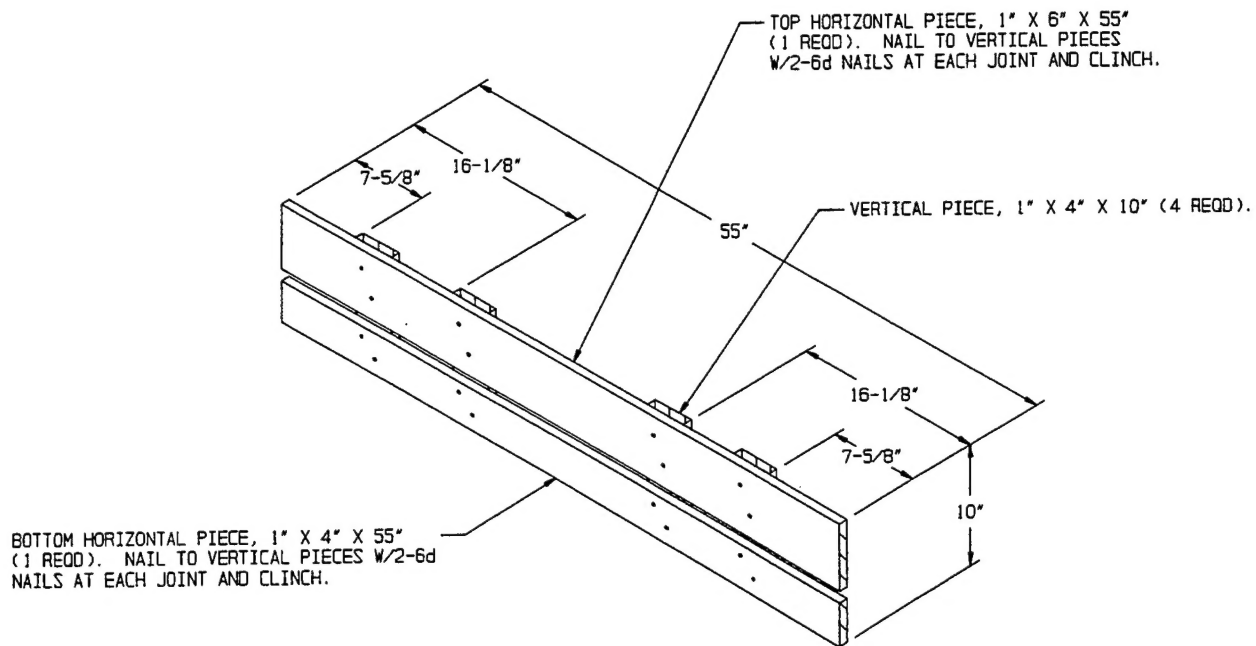
## BILL OF MATERIAL

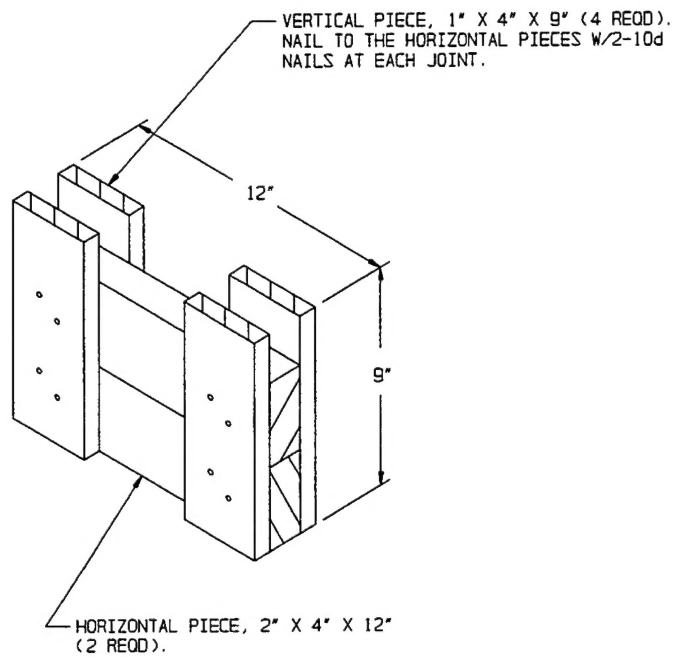
LUMBER	LINEAR FEET	BOARD FEET
1" X 4"	33.08	11.03
1" X 6"	13.75	6.88
2" X 4"	4.00	2.67
NAILS	NO. REOD	POUNDS
6d (2")	32	0.19
10d (3")	32	0.49
PALLET, 27-1/2' X 55" - - - 1 REOD - - - - -	54 LBS	
STEEL STRAPPING, 3/4" - 48.00' REOD - - - - -	4.29 LBS	
SEAL FOR 3/4" STRAPPING - - 5 REOD - - - - -	NIL	

## MATERIAL SPECIFICATIONS FOR UNIT LOAD

PALLET - - - - -	FOR PALLET MATERIAL SPECIFICATIONS SEE PAGE 6.
LUMBER - - - - -	SEE TM 743-200-1 (DUNNAGE LUMBER) AND FED SPEC MM-L-751.
NAILS - - - - -	FED SPEC FF-N-105; COMMON. ALT: ANNULAR-RING TYPE NAIL, PALLET TYPE (MECHANICALLY DEFORMED) NAIL, OR COOLER NAIL OF SAME SIZE.
STRAPPING, STEEL - -	ASTM D3953; FLAT STRAPPING, TYPE I, HEAVY DUTY, FINISH B (GRADE 2), SIZE 3/4" X .035" OR .031".
SEAL, STRAP - - - -	ASTM D3953; CLASS H, FINISH B (GRADE 2), DOUBLE NOTCH TYPE, STYLE I, II, OR IV.

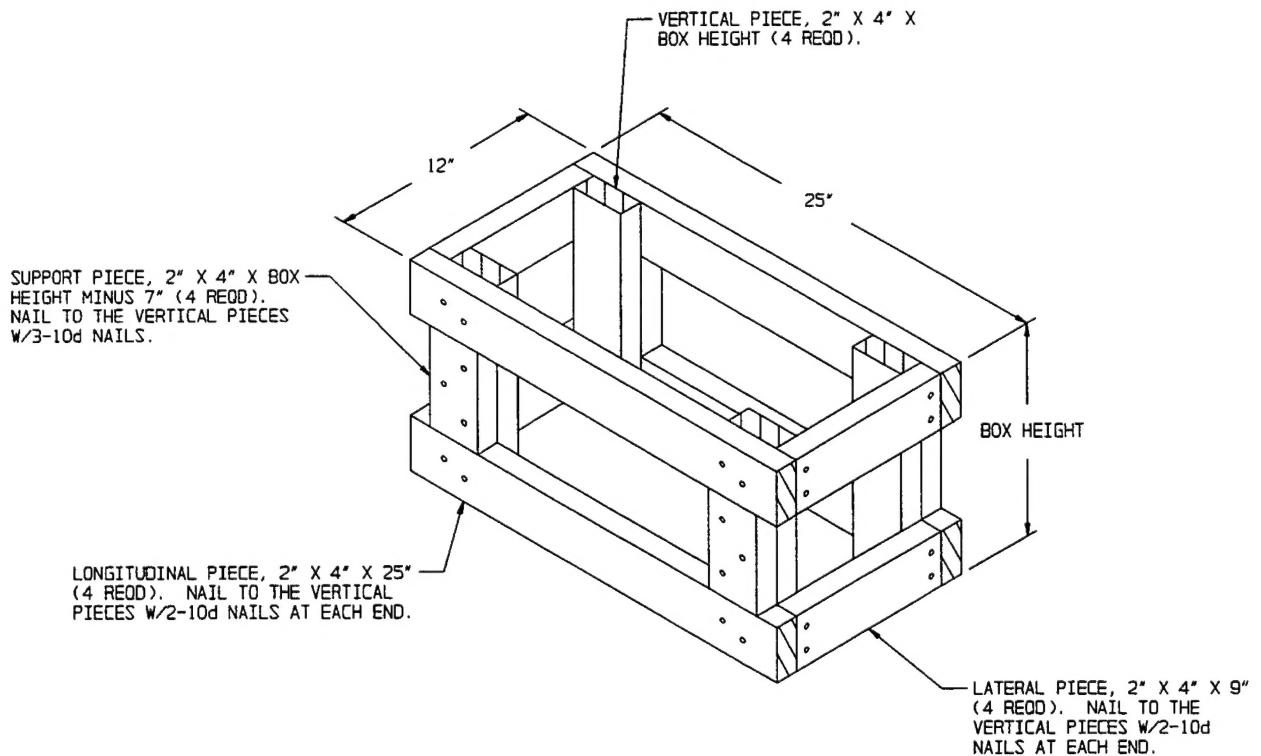






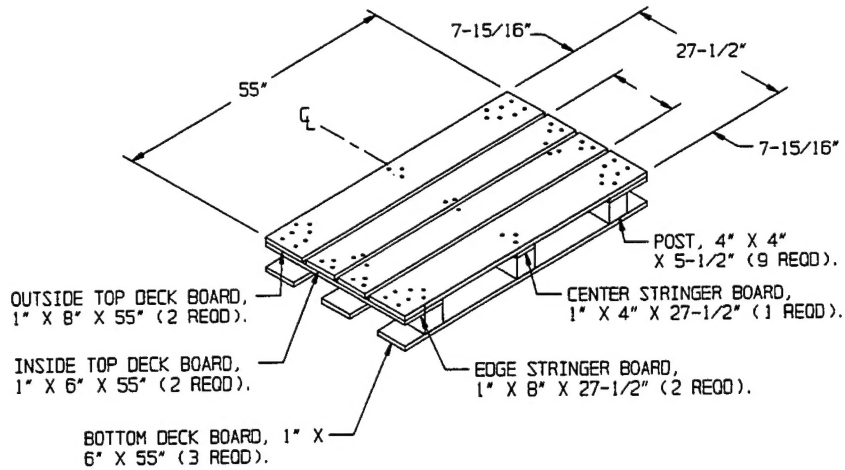
#### END FILLER ASSEMBLY

(2 REQD)



#### FILLER ASSEMBLY

(2 REQD)



BILL OF MATERIAL FOR PALLET		
LUMBER	LINEAR FEET	BOARD FEET
1" X 4"	2.29	0.76
1" X 6"	22.92	11.46
1" X 8"	13.75	9.17
4" X 4"	4.13	5.51
NAILS	NO. REQD	POUNDS
1-5/8"	28	0.17
2-1/4"	27	0.27
3-1/4"	27	0.47

SPECIAL NOTES:

- MODIFIED STYLE 1A MIL-P-15011 PALLET.
- MATERIAL: WOOD, MIL-STD-731, GROUP III OR IV. FED SPEC FF-N-105, TYPE II, STYLE 18 PALLET NAILS. EXCEPT THAT THE NAIL POINT MAY BE DIAMOND (NOT LONGER THAN 5/32 INCH), OR CHISEL PROVIDED THE WIDTH DOES NOT EXCEED THE WIRE DIAMETER.
- NAIL OUTSIDE TOP DECK BOARDS TO STRINGER BOARDS WITH FOUR 1-5/8 INCH 11 GAGE DRIVE-SCREW NAILS AT EACH JOINT. NAIL INSIDE TOP DECK BOARDS TO STRINGER BOARDS WITH THREE 1-5/8 INCH 11 GAGE DRIVE-SCREW NAILS AT EACH JOINT. NAIL THRU TOP DECK BOARD AND STRINGER BOARD INTO POSTS WITH THREE 3-1/4 INCH 10 GAGE DRIVE-SCREW NAILS. NAIL EACH BOTTOM DECK BOARD TO POST WITH THREE 2-1/4 INCH 11 GAGE DRIVE-SCREW NAILS.